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SPECTRA
40 YEAR ANNIVERSARY

The Future for Open and Enterprise Tape formats ?

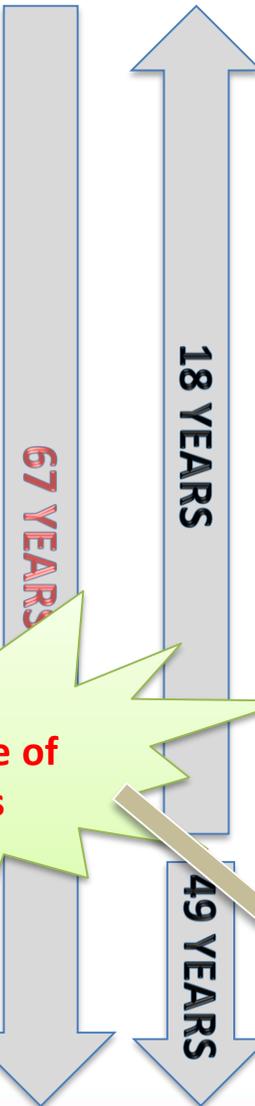
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Agenda

- A history lesson (to set some perspective)
- Tape primer
- Open (LTO) versus Enterprise
- So who and what is left in the tape space?
- What about media? (the actual tape)
- So how does this help me as a DMF user? (WiiFM)
- Final thoughts - how can we take advantage of these new technologies, and what are the upsides and downsides?
- So which way Enterprise or Open?

Compounding growth In Tape's Capacity



2018	3592 JE	8,704 tracks	20,000 GB (20 TB)
2018	LTO 8	6,656 tracks	12,000 GB (12 TB)
2015	LTO 7 / Type M	3,584 tracks	6,000 / 9,000 GB (6-9 TB)
2014	3592 JD	5,160 tracks	15,000 GB (15 TB)
2013	T10K D	4,608 tracks	8,500 GB (8.5 TB)
2012	LTO 6	2,176 tracks	2,500 GB (2.5 TB)
2011	T10K C	3,584 tracks	5,000 GB (5 TB)
2011	3592JC	2,560 tracks	4,000 GB (4 TB)
2010	LTO 5	1,280 tracks	1,500 GB (1.5 TB)
2008	T10K B / 3592 JB	1,152 tracks	1,000 GB (1 TB)
2007	LTO 4	896 tracks	800 GB
2007	3592 JA	896 tracks	500 GB
2000	LTO 1 / 2 / 3	384 / 512 / 704 tracks	100 / 200 / 400 GB
1999	DLT4	168 tracks	40 GB
1995	MTC Magstar 3590	128 tracks	10 GB
1992	MTC 3490E	36 tracks	800 MB
1985	MTC 3480 Tape	18 tracks	210 MB
1951	Open Reel Tape	9 tracks	200 MB



CAGR 34%

CAGR 11%

First occurrence of "tape is dead"

First a test ... What are these ?



LTO-8 Open drive Standard Specifications

- Cartridge Capacity: 12 TB native and 30 TB compressed*
- LTO-7M: media available – 9TB (an LTO7 formatted as 9TB)
- Data Transfer Rate: 360 MB/s native and up to 750 MB/s compressed* (HH drive is 300 MB/s and slightly slower rewind time - 3 seconds.)
- Automatic Speed Matching: For compatibility with your existing system
- Interface: 8Gb/s Fibre Channel (auto-negotiates to 4Gb/s or 2 Gb/s); 6 Gb/s SAS (auto-negotiates to 3Gb/s)
- Encryption: AES256-GCM
- Media: Sony and Fujifilm are manufacturers

ULTRIUM
LTO **8**



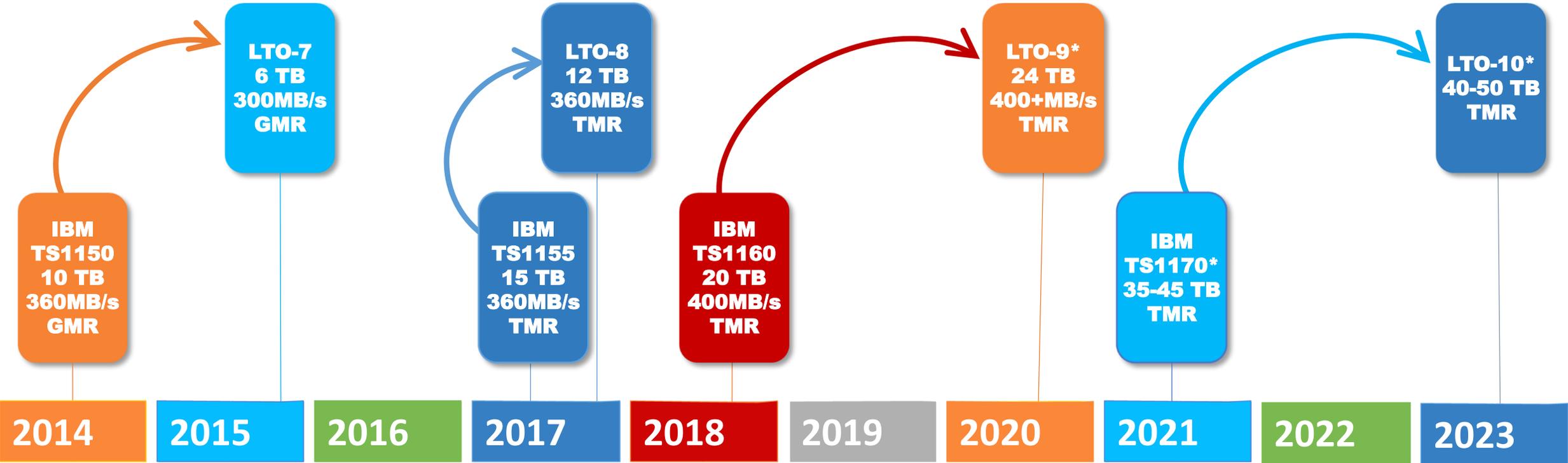
* 2.5:1 Compression

TS1160 Enterprise drive

- Released and shipped in December 2018
- 20TB native capacity with new JE media
 - 15TB native capacity with existing JD media
- 400 MB/s native throughput
- 16G fibre channel
- 10GbE or 25GbE RoCE
- Uses existing TMR head from TS1155 and LTO-8
- Uses new Bara ASIC and new main drive control board



Tape Technology Roadmap Tick Tock – just like CPU's

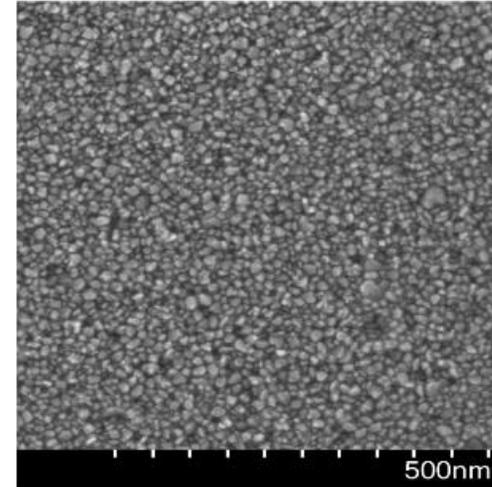
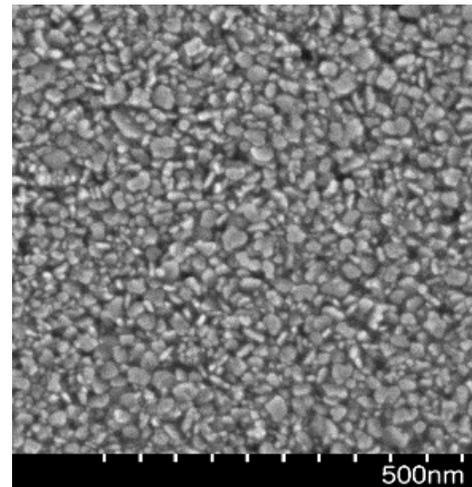
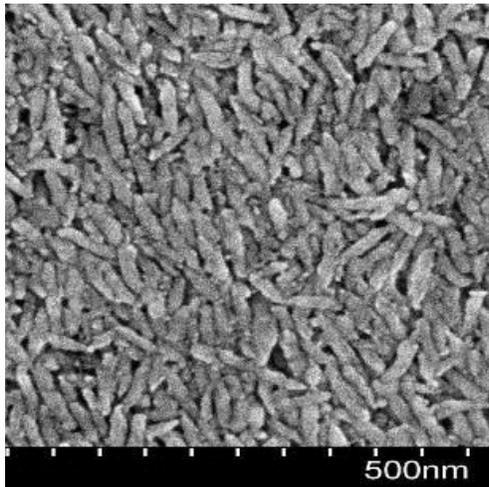
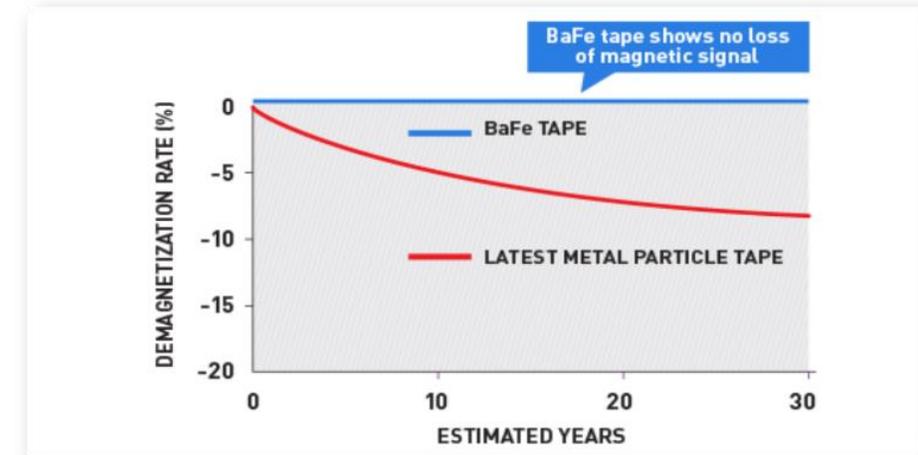


So what are the differences – Open versus Enterprise

- Toyota versus Lexus (same development path, same manufacturer.)
- “Up-formatting” (aka media re-use): Enterprise = YES, Open = NO (*except LTO7-M in LTO-8 drive - concession)
- Media: Enterprise = new drive leverages existing media (every other drive*) , Open = New drive, new media
- Media support: Enterprise = (current plus 2 gen back, 1 RW, 1RO*)
- Media Support: Open = current plus 1 gen back (previously 2 generations: 1 RW + 1 RO)
- Ethernet to drive (RoCE): Enterprise = YES, Open = NO but... (Spectra Swarm)
- RAO (Random Access Order) Enterprise = YES, Open = NO but... (Spectra TAOS)
- Head tape path and servo – pretty much the same, but minor load unload/rewind differences <5% (minor differences)
- Buffer cache – larger in (Enterprise 2GB v Open 1GB)
- BER (Bit Error Rate) Enterprise = 10^{-20} Open = 10^{-19}
- Encryption – same LZ1 AES 256 bit
- Power consumption: Enterprise 46W per drive Open 31W per drive
- MTBF – same 250,000 hours MSBF (Mean Swaps Between Failures) 100,000 v 300,000
- Pricing: Enterprise drive (usually 2x FH Open drive, 2.5x HH Open drive)
- Media – Enterprise media is more expensive and drops less per year (no competition but you get more native TB and up-formatting)

So what about the media?

- How many “manufacturers” left ?
- Two - Sony and Fuji.
- MP – BaFe – SrFe (LTO10+)



**Onto Media - Today's tape has 8,704 tracks
on ½ inch (12mm) – equivalent to:**

**79 TRACKS ON A SINGLE
STRAND OF HAIR**

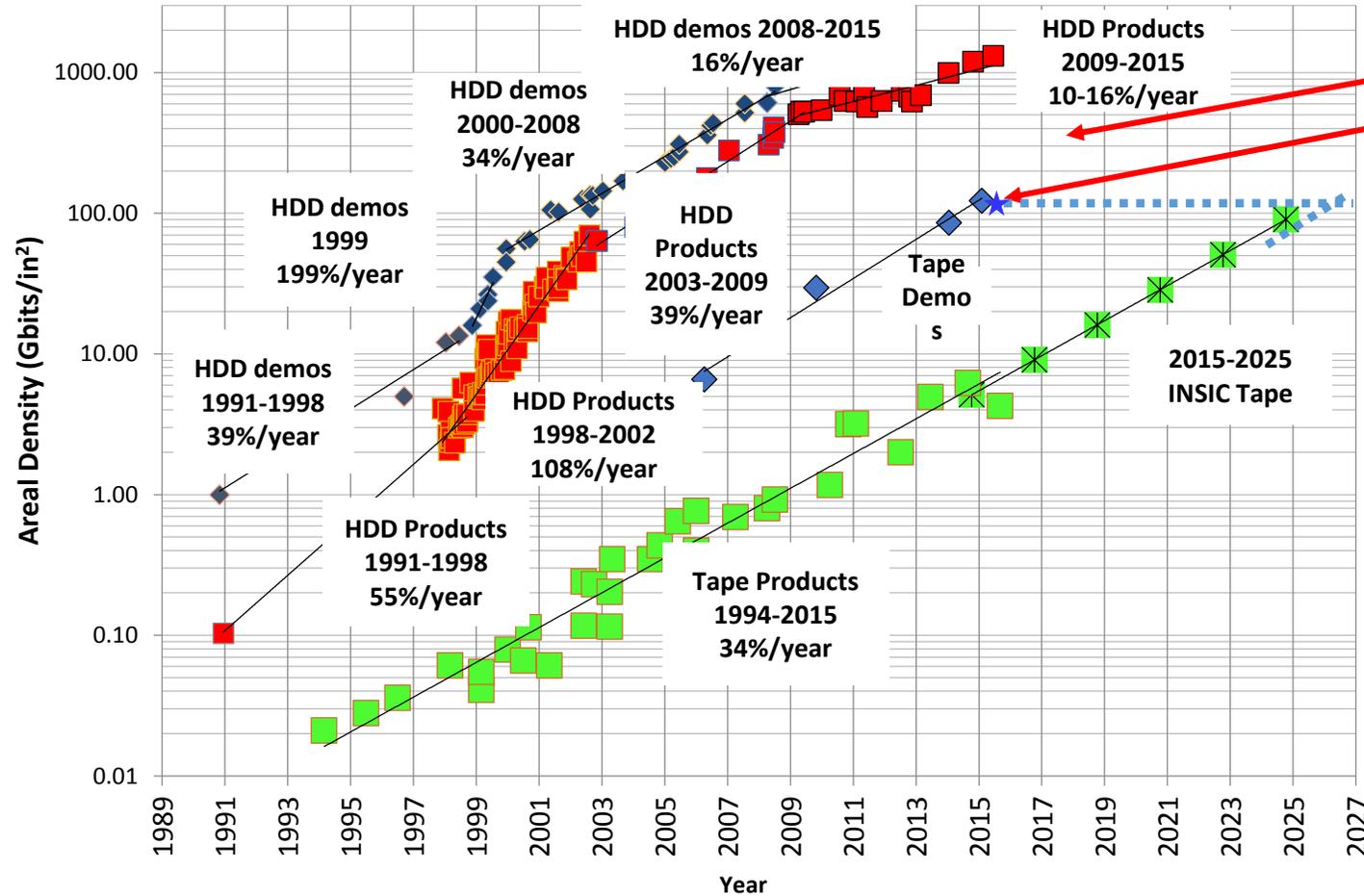


HDD vs. Tape Areal Density Scaling:

IBM-FujiFilm demonstration of 123 Gb/in² on BaFe tape (2015)

IBM-Sony demonstration of 201 Gb/in² on Sputtered media (2017)

Goal: Demonstrate the feasibility of tape roadmap for the next 10+ years



201 Gbit/in² demo

123 Gbit/in² demo

330TB Sputtered Media - Sony

220TB BaFe Fuji

(Source: INSIC 2012-2022 International Magnetic Tape Storage Roadmap)

2015 Storage Bit Cells and Extendibility

- Scaled bit cells:



- Magnified 25x:

Tape has *a lot* more room to play with



NAND Flash (3 bits) 2150 Gb/in²
17.3 nm x 17.3 nm



HDD 1000 Gb/in²
47 nm x 13 nm



Optical blu ray (3 layer) 75 Gb/in²
~114 nm x 79 nm

LTO7Tape ~4.3 Gb/in²
2850 nm x 52 nm

Jag5 Tape ~6.7 Gb/in²
2210 nm x 49 nm



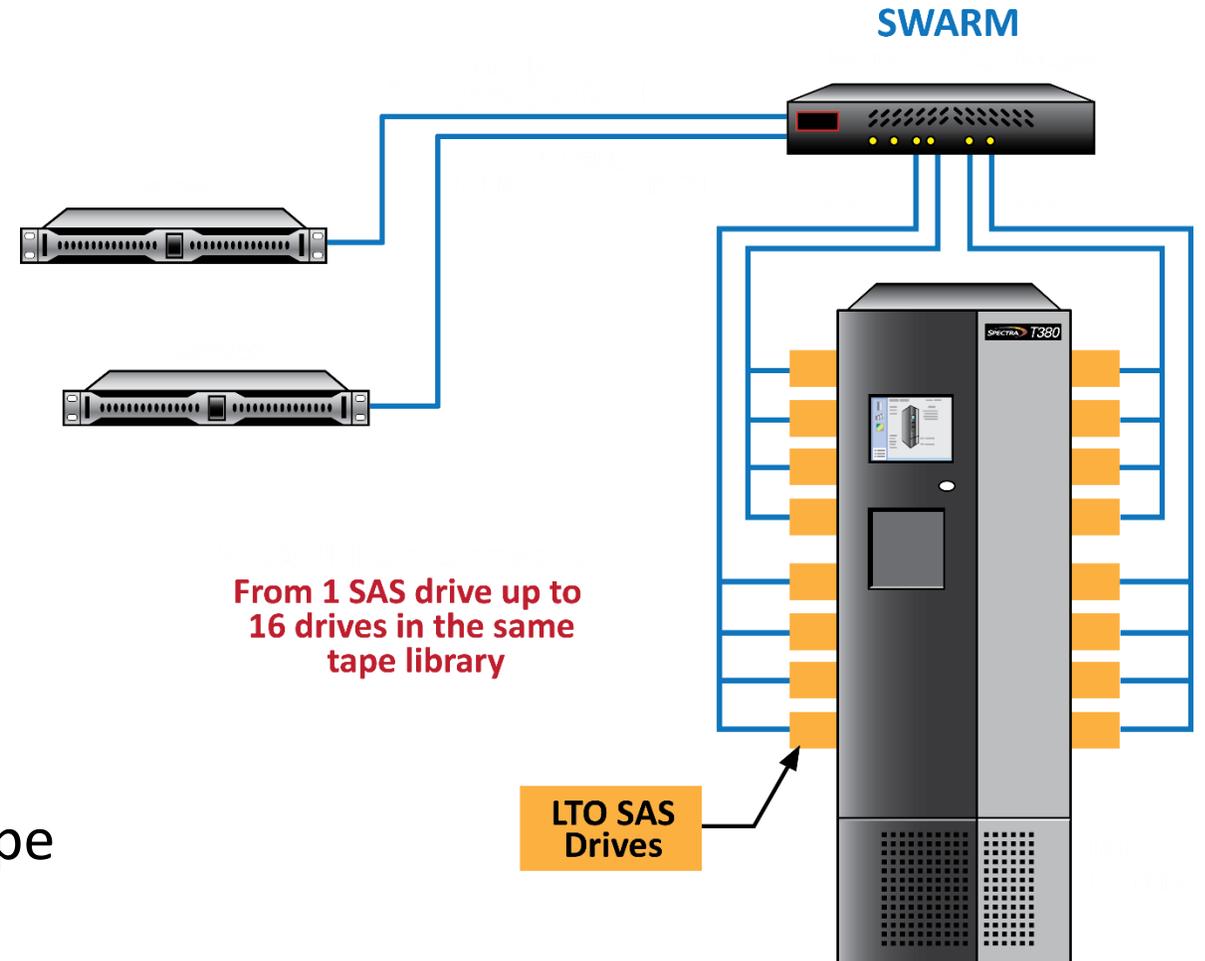
Demo 123 Gb/in²
140 nm x 37 nm

→ Tremendous potential for future scaling of tape track density

→ Key technologies: improved track follow servo control improved media, reader, data channel

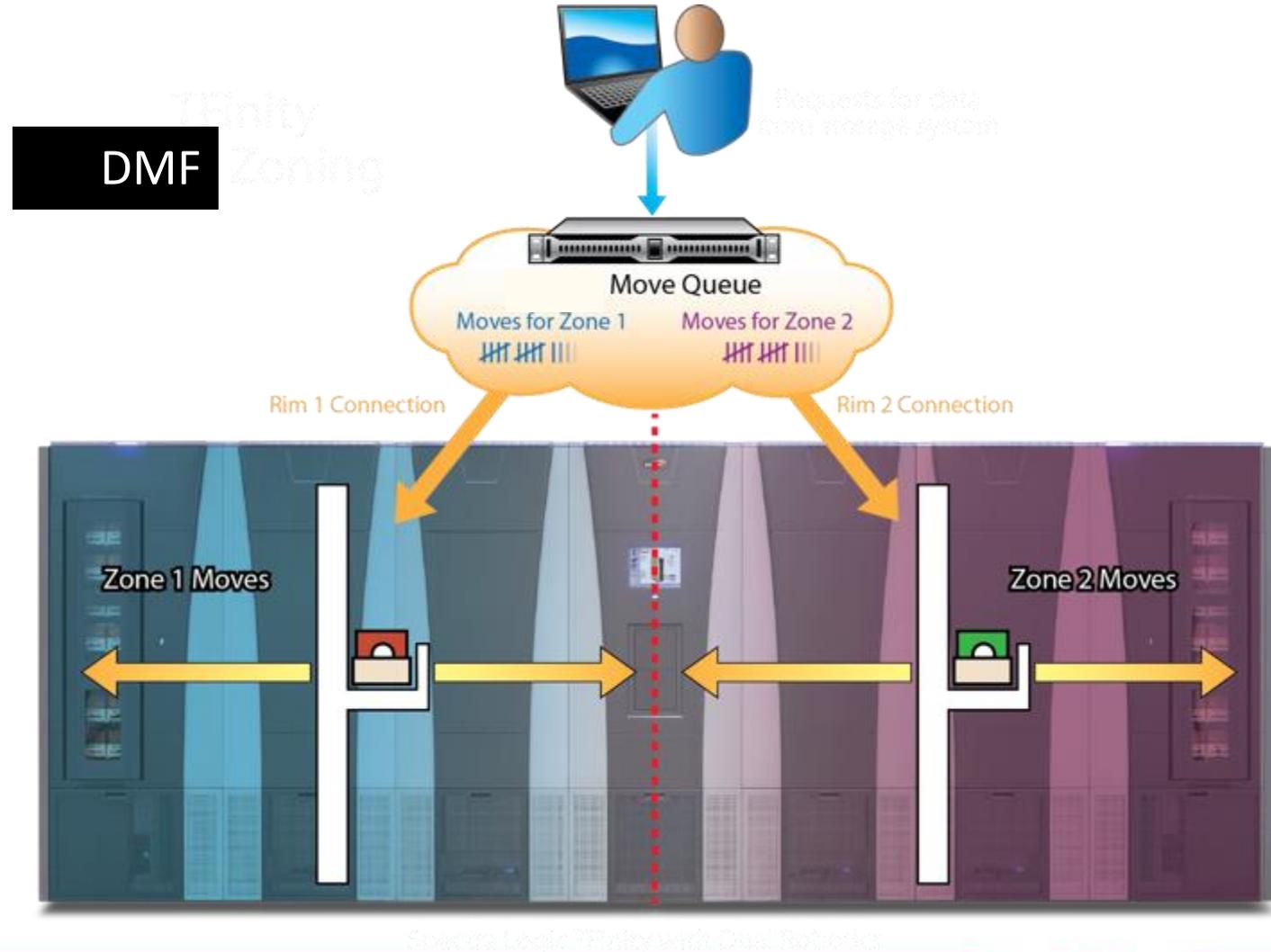
Entertaining Open formats? - Ethernet LTO drive support

- By using an Ethernet to SAS bridge in a Spectra Logic Tape library there is now an option for connecting LTO drives over an Ethernet interface to a host
- The bridge is incorporated into top of the library or in rack.
- Two 40GbE ports into tape system and 16 SAS connections to tape drives
- Full bandwidth with RoCE to all 16 tape drives when both 40GbE ports are used to attach to host
- Full RoCE v2 or iSCSI support. Host sees tape drives as RoCE or iSCSI connections
- Solution uses SAS tape drives



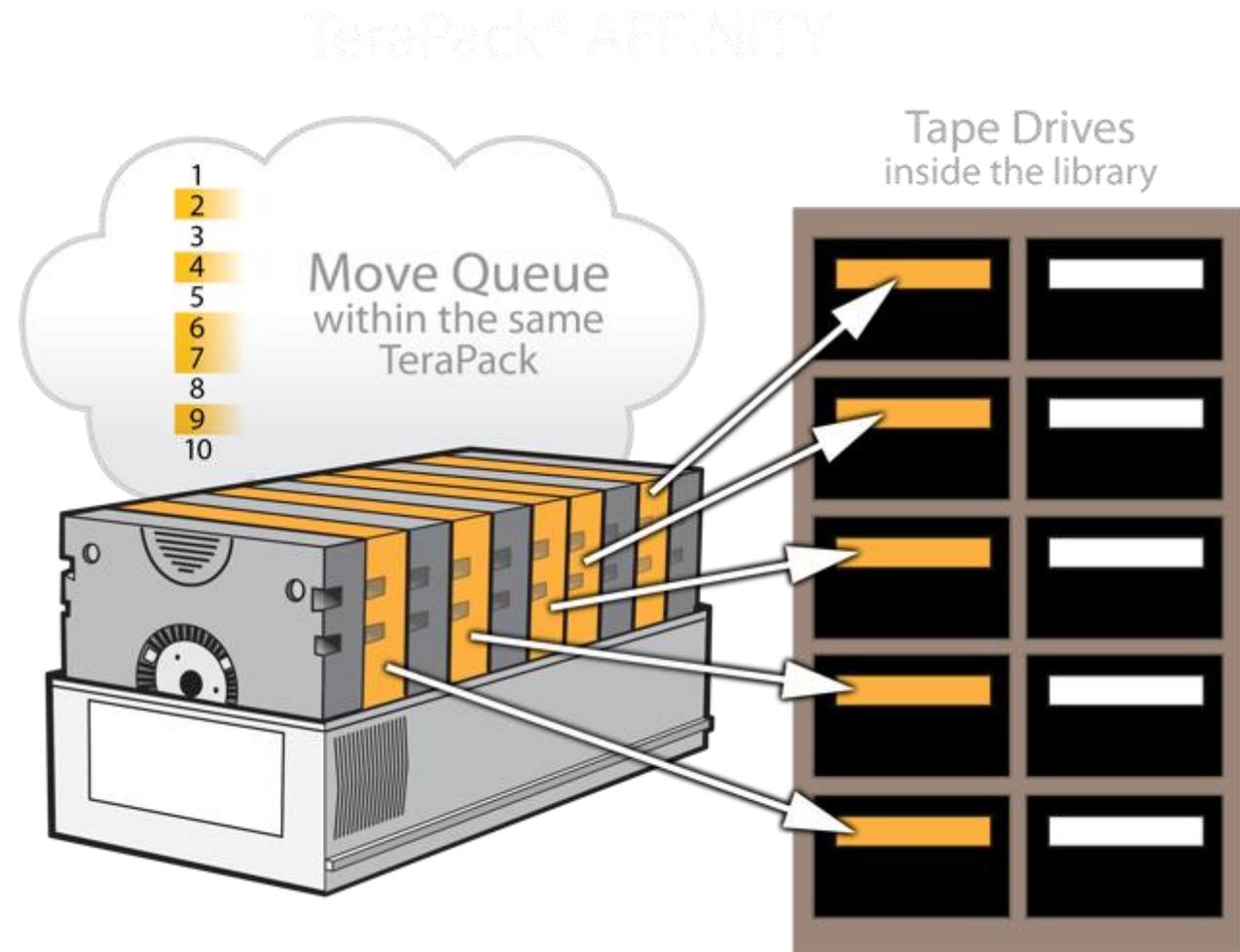
DMF Optimizations for TFinity - Zoning

- The TFinity Bluescale software has been modified to include zoning information in the Read Element Status response.
- This allows the DMF software to keep both robots working optimally in their zone without any robotic contention.



Spectra TFinity TeraPack[®] Affinity

- Complete as many tape moves as possible from the same TeraPack to increase overall robotic performance.
- By giving DMF the TeraPack barcode associated with each tape barcode they can sort their internal move queue to consolidate all tape moves within a given TeraPack to happen in order.



Objectives Of Spectra TAOS™

- Does not add cost to existing libraries (standard BlueScale™ feature)
- Nearly identical SCSI interface to RAO SCSI commands implemented in TS11xx drives
- Support LTO-7, 8 and future LTO drives. Evaluating LTO-6 media in LTO-7 drive
- Improve performance of restore operations
- Reduce tape media wear
- Reduce tape drive wear

Spectra TAOS

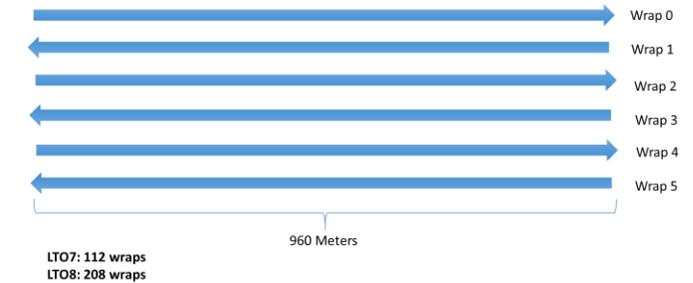
Software Driven

- Taos is driven by host software packages that are block address aware of their files stored on tape. Much like how block based disk is managed by these packages.
- Typically will be HSM software
- Nearly identical SCSI interface to TS115x RAO (Recommended Access Order) SCSI commands used by HSM software packages today.
- First adopters HPSS and DMF
- Will have a spec for other software developers to develop against.
- LTO7, LTO8 and future LTO supported.

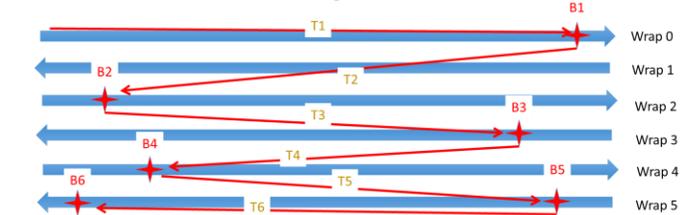
Implementation Details

- Simple software upgrade for application that already support RAO
 - TAOS command shows up on LUN1 of each tape drive within a spectra library
 - LUN1 of each drive in the partition reports as a Media Changer Device, and the vendor/product field identifies as a special library that supports the TAOS commands.
 - We have chosen this to be a Media Changer Device so as not to interfere with other possible operations.
 - This library will have zero slots and zero drives. It will only support Inquiry, TUR, Request Sense and both the GTAOS and RTAOS commands.
 - The Generate Time-Based Access Order System and Receive Time-Based Access Order System CDBs must be sent to LUN1 of the drive that has the tape loaded.
- TAOS SCSI request and response is almost identical to that of RAO
- The partition wizard will have a checkbox to enable this feature.

Tape has a serpentine pattern



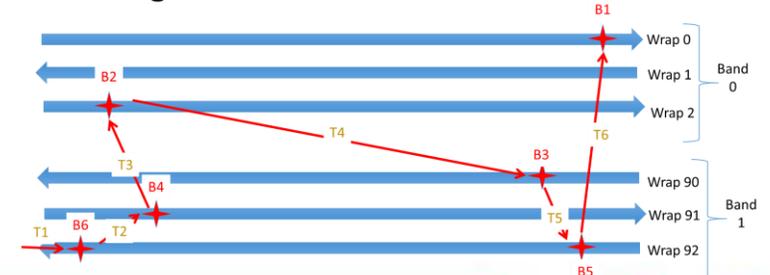
Linear recalls are very inefficient



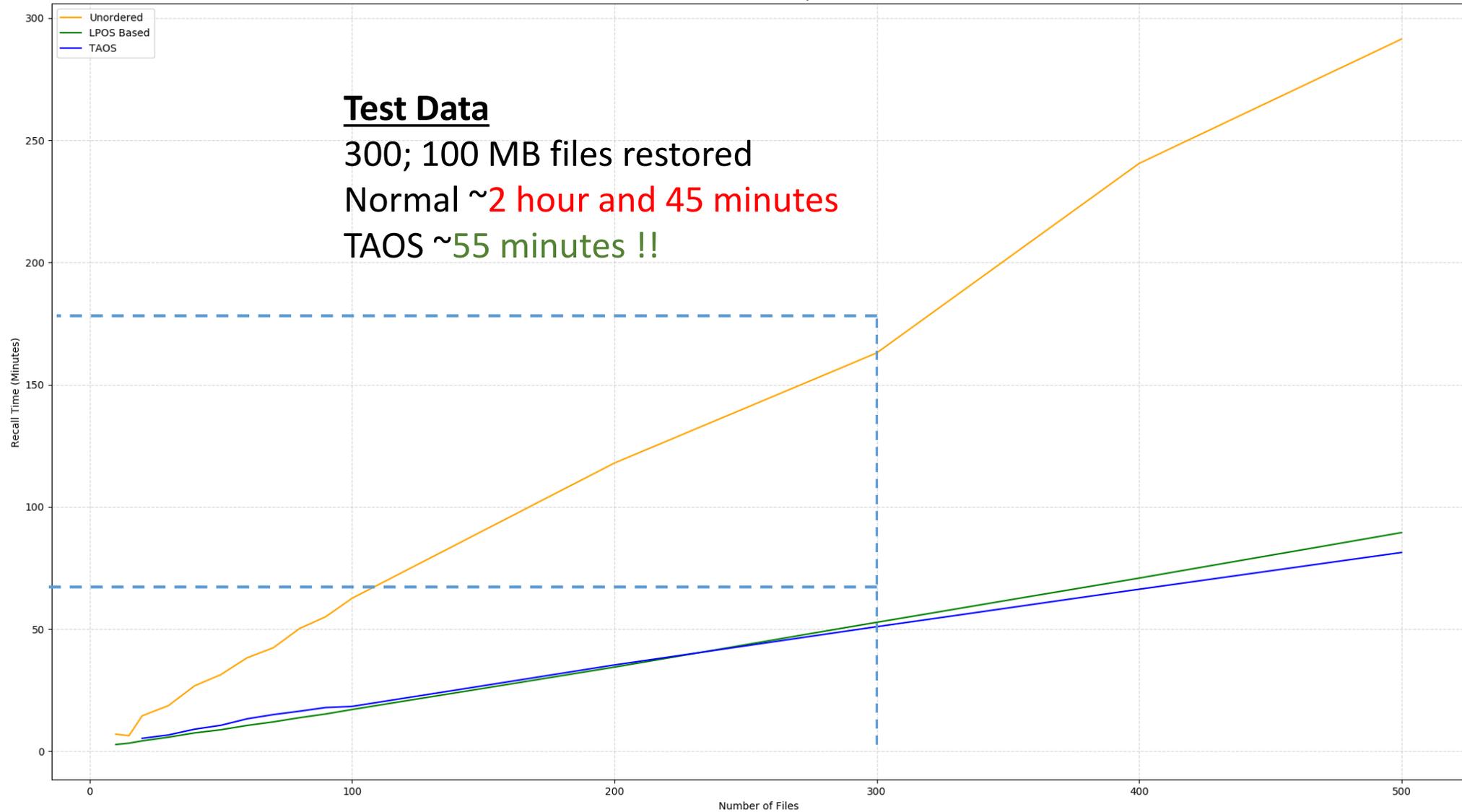
Ordered recalls are much more efficient



Crossing Bands Is Considered



Recall Time of Random Jobs
100MB Reads - LTO7 Tape Drive



Test Data

300; 100 MB files restored

Normal ~2 hour and 45 minutes

TAOS ~55 minutes !!

Spectra TAOS - Media and Drive Wear Reduction Testing

- Tests were performed with 100 files with a file size between 1-100MB:
- TAOS Meters of Tape Across the Drive Head: 2,470
- Unordered Meters of Tape Across the Drive Head: 31,878
- A ~13x reduction in meters of tape. Or 8.4% of the original meters of tape.
- Spectra currently estimates that TAOS will reduce tape and drive wear by ~10X on media read operations when used in conjunction with HPSS 7.5 and DMF
- NASA Ames testing with DMF

Spectra BlueScale - Programmatic Interface

- XML Based Interface
- Status of controllers
- List and Status of all drives
- Inventory
- Retrieve and Set Configuration
- Import and Export Inventory
- System Messages
- Spectra API - Working in collaboration with LLNL to create an open source Python 3 application that makes scripting commands easy.
<https://github.com/LLNL/slapi>



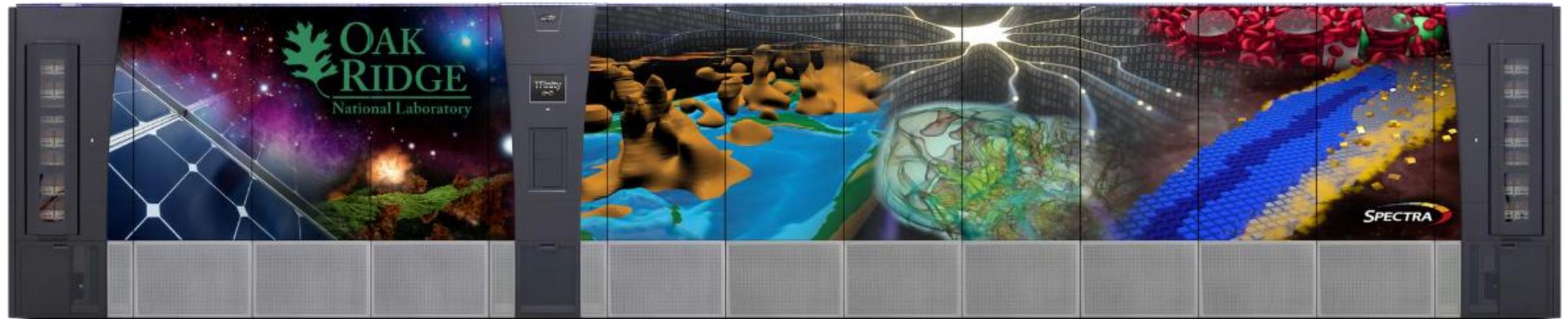
Spectra Tri-media - Three Different Tape Technologies in the same library

- Spectra's ExaScale Edition tri-media feature now allows migrating or integrating your existing T10K media & drives.
- The ExaScale Edition TFinity supports mixed media environments with LTO, TS, and T10K.
- Spectra Logic offers a migration program where your existing T10K drives can be resledded into TFinity drive sleds and then used for recalling data from existing T10K media, reducing initial migration costs.



Custom Skins

The range of possibilities for customizing your ExaScale TFinity are almost boundless. Organizations can graphically customize panels nearly any way they would like.



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The Future for Open and Enterprise Tape formats ?

Strong drive and media roadmap that is joined at the hip.. You choose – You'll do well with either.

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Cloud

- What does your CIO think it is built on? Unicorns and rainbows?
- Latest buzz word like “Agile” “BigData” “Cryptocurrency” or “IoT” ...
- Or actually, the same infrastructure that you can own, **holding YOUR data and rented back to you at a profit !!**

